Space Weather Technical Forecast

Issued on Wednesday, 04 January 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Moderate solar activity throughout. Active electron fluence expected through 04 January, then likely declining. Chance of G1/Minor Geomagnetic Storm intervals on 04/05 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with no significant flares from the five regions on the visible disc. The most active visible region was AR3180 in the northeast, which has produced a series of low-level C-class flares. The remaining regions on the visible disc are all rather small and magnetically simple. A region beyond the southeast limb produced a long-period C4.0 flare starting around 03/0620 UTC. This produced a large, fast CME which has been modelled, but does not have an Earth-directed component. No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed at L1 showed a continued declining trend between 03/0001 and around 03/1200 UTC, falling from 430km/s to around 360km/s. Following this a slow increase, followed by a more rapid increase after 03/1800 UTC was observed, reaching speeds of 430-450km/s by 03/2130 UTC after which, no DSCOVR or ACE data has been available. Density has predominantly been at below average levels, though has increased to persistently average levels from around 03/1900 UTC and briefly above average around 03/2100 UTC. Total magnetic field strength was mostly weak, but increased to moderate around 03/2100 UTC, with a peak of 9nT. The north-south component, Bz, varied weakly but varied moderately after 03/2100 UTC. Phi angle was predominantly positive (towards the Sun), but has varied periodically since around 03/1500 UTC but with occasional incursions into the negative (away from Sun) sector. The source of the changes in more recent hours, although somewhat uncertain, is speculated to be an interaction with the Heliospheric Current Sheet, potentially followed by a glancing blow from a CME that left the Sun on 30 December. Resultant Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) has been at mainly high levels, with a peak of 4100 pfu at 03/1605 UTC before dropping to moderate, occasionally background levels from 03/2214 UTC. The 24-hour integrated electron fluence has been above the Active threshold throughout. The observed fluence at 03/2359 UTC was 1.43e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Mainly Low solar activity is expected on 04 January, with an increased chance of M-class and X-class flares from 05 January due to the apparent active regions beyond the eastern limb, soon to become visible from Earth.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs are currently expected during the four-day forecast period. Solar wind speeds are presently at Slightly Elevated levels owing to the recently speculated arrival of a CME and/or Sector Boundary Crossing of the Heliospheric Current Sheet. The high speed streams from negative coronal holes 60 and 61 are due to affect the Earth either on 04 or 05 January (Day 1 or 2), with estimated speeds in the region of 450-500km/s. These Slightly elevated to Elevated solar wind speeds are expected to persist to the

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end of the forecast period with a slow downward trend from the 05 or 06 January. Geomagnetic activity will generally be Unsettled through the next 24 hours, but with an increasing risk of Active or G1/Minor Storm intervals due to any possible residual CME effects and then the anticipated onset of one or more HSS later on 04 or early 05 January. Further G1/Minor Storm intervals are then possible through 05 January due to the effects of any HSS connection, with a return to Quiet to Unsettled conditions expected by 06 January (Day 3).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout but with a chance of rising alongside any notable flares, giving a slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) at GOES-16 have fallen to moderate to background levels, but may increase again on 04/05 January (Day 1/2) back to High levels. Further more persistently reduced flux levels are likely from 05 January due to the possible effects of the coronal hole high speed stream connections, but there is low confidence in the impact of these effects. Later on 06 or 07 January (Day 3 or 4), flux could increase back to persistently High levels again as geomagnetic activity subsides. Electron fluence levels are expected to remain above the Active threshold for a time on 04 January, but with greater uncertainty from 05 January due to the potential geomagnetic enhancements.

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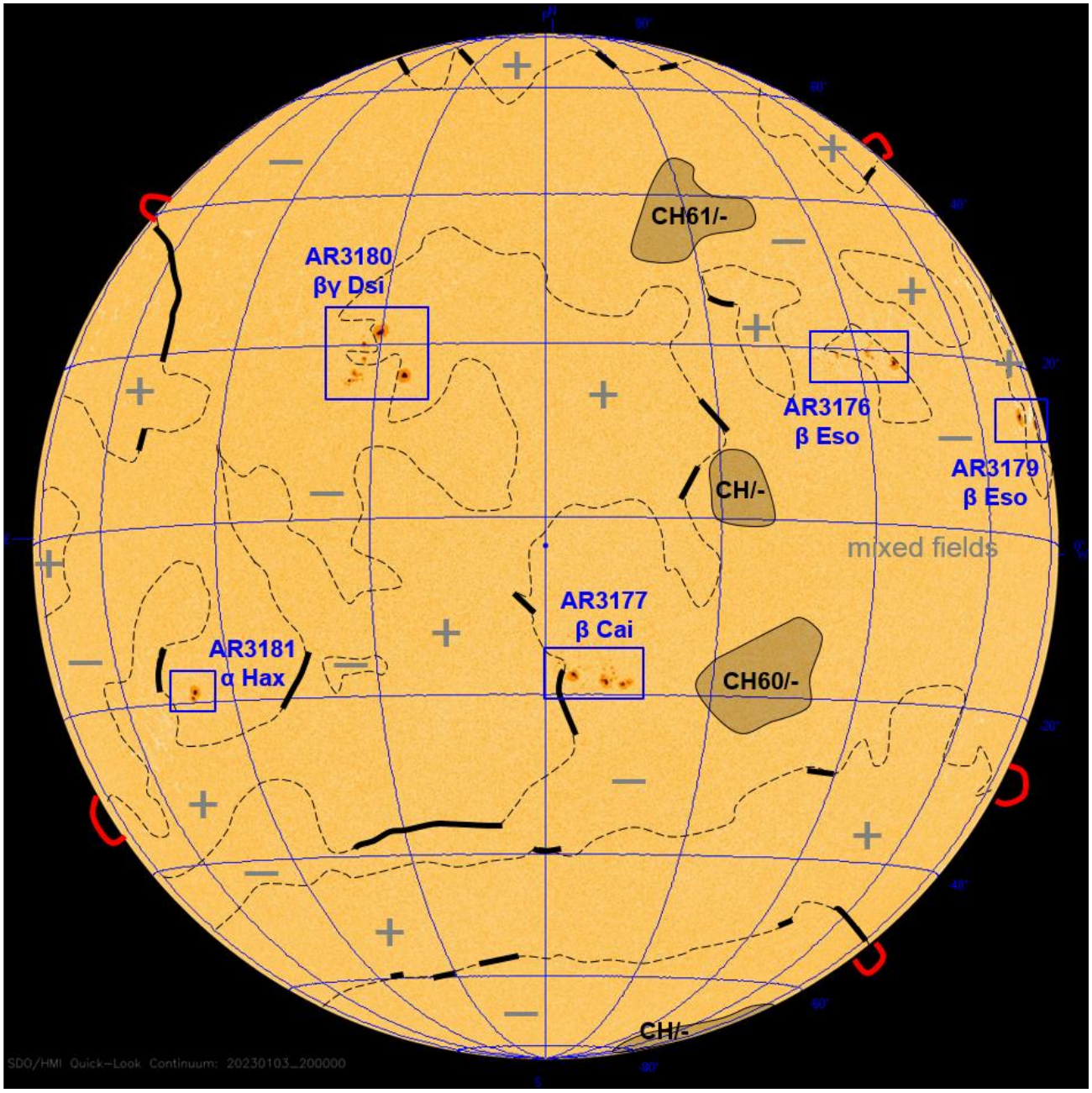
Figure 1. Solar Analysis Valid 03/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 30 December may have have arrived at Earth, late on the UTC day on 03 January. No other Earth-directed CMEs are currently expected during the four-day forecast period.

Solar wind speeds are presently at Slightly Elevated levels owing to the recently speculated arrival of a CME and/or Sector Boundary Crossing of the Heliospheric Current Sheet. The high speed streams from negative coronal holes 60 and 61 are due to affect the Earth either on 04 or 05 January (Day 1 or 2), with coronal hole 60 likely to produce a stronger connection due to the relative position of Earth to the coronal hole. Analysis of STEREO-A data suggests that the hole has still not yet connected with the spacecraft, suggesting that any connection at Earth will more likely be early on 05 January. In the absence of observations for the high speed stream from STEREO-A, speeds of 450-500km/s are estimated given an apparent decline in the size of the coronal hole since the past rotation in early December. Slightly elevated to Elevated solar wind speeds are then expected to persist to the end of the forecast period with a slow downward trend from the 05 or 06 January.

Geomagnetic activity will generally be Unsettled through the next 24 hours, but with an increasing risk of Active or G1/Minor Storm intervals due to any possible residual CME effects and then the anticipated onset of one or more HSS later on 04 or early 05 January. Further G1/Minor Storm intervals are then possible through 05 January due to the effects of any HSS connection, with a return to Quiet to Unsettled conditions expected by 06 January (Day 3).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	40	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections - Nil

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Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the last 24 hours, with five sunspots currently on the visible disc. AR3180 is the most active region, producing a number of low level C-class flares as the region slowly evolves. All other regions are relatively small and magnetically simple. The largest flare observed during the past 24 hours was from a region beyond the east limb, producing a long period, C-class flare, peaking at C4.0. However, with a large portion of the flux being obscured by the solar disc, the actual flare size is likely to have been much larger than this. Based on the rotation of the sun, the source of the flare is likely to be old AR3163 from December. As this region and others rotate onto the visible disc in the next day or two, the risk of both M-class and X-class flares are increased between Day 1 levels on 04 January and Day 2 on 05 January.

Mainly Low solar activity is expected on 04 January, with an increased chance of M-class and X-class flares from 05 January due to the apparent active regions beyond the eastern limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	50	50	50
Very Active	R3 to R5 X Class	No	5	10	10	10

Figure 2: GOES 16/17 X-ray flux for the past 24-hours.

Figure 3: STEREO A EUVI 195 imagery at 03/0635 UTC showing significant X-ray flaring from region on eastern limb. This region will rotate onto the Earth-facing disc in the next 24-36 hours.

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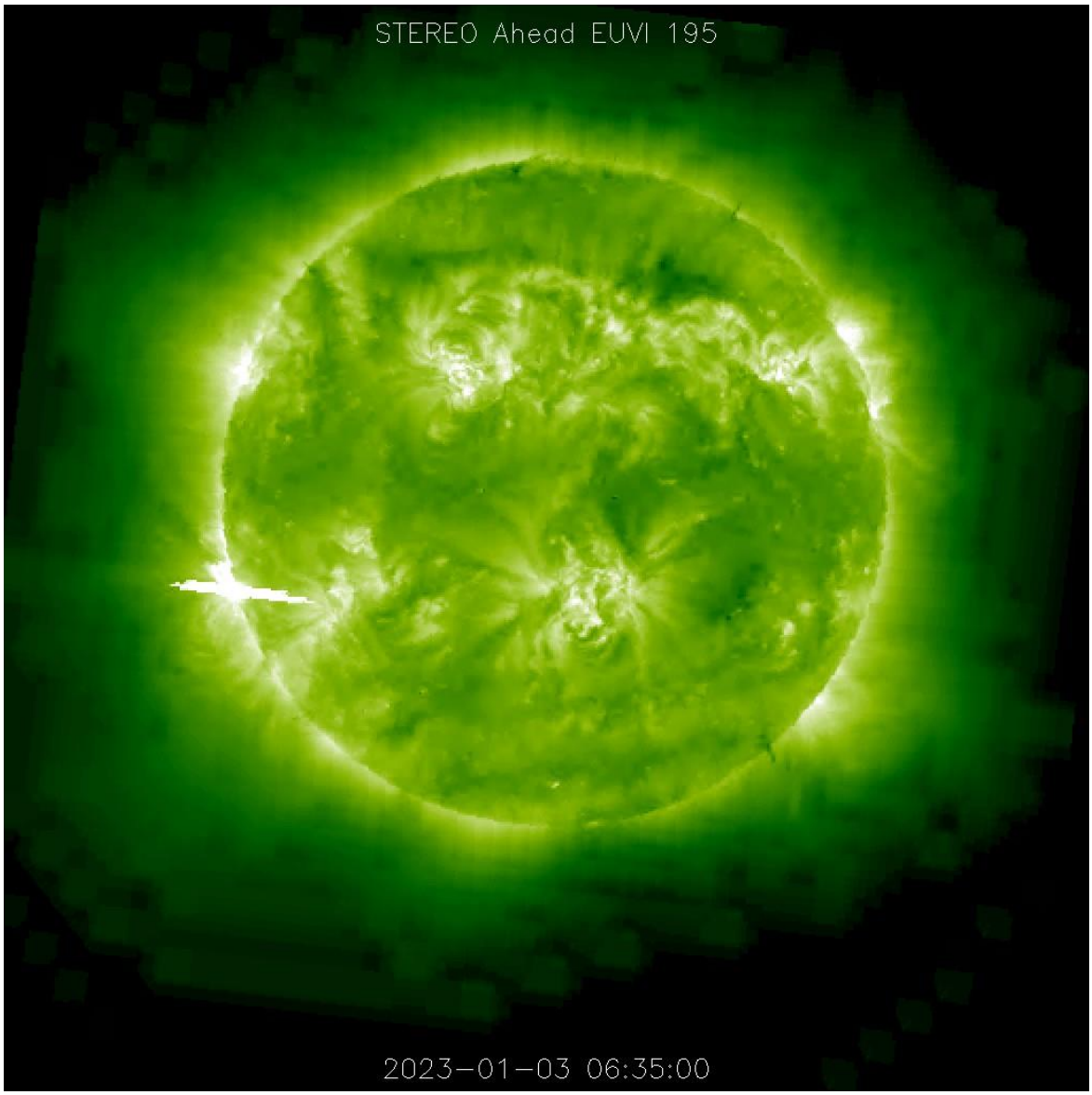
Space Weather Technical Forecast



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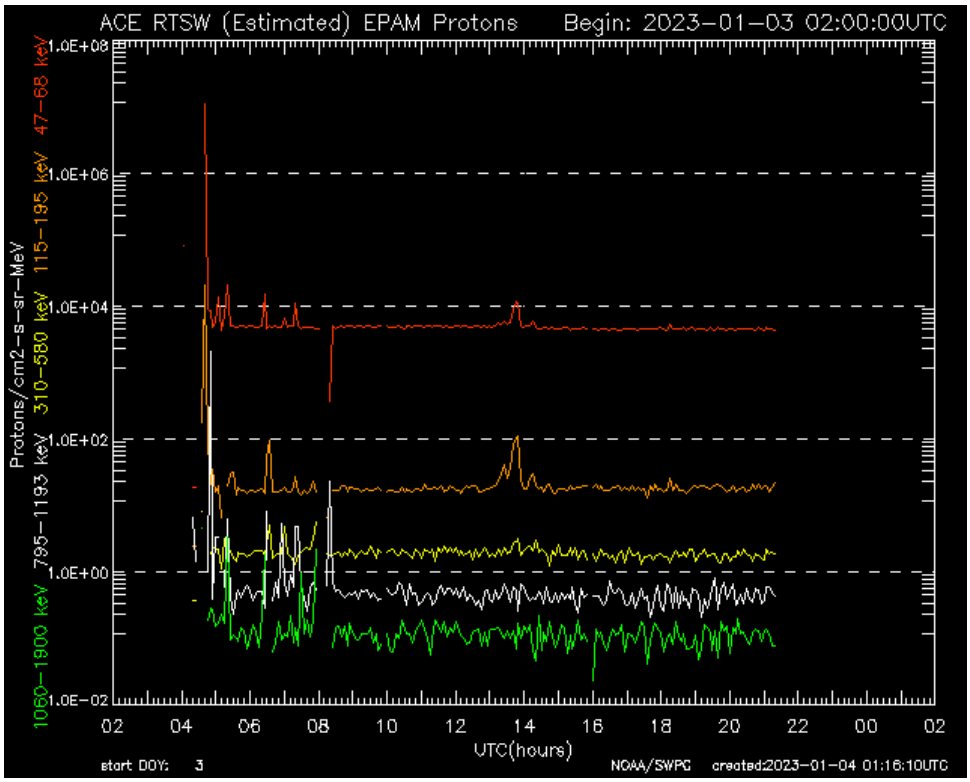
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases slightly through the period, due mainly to the risk presented by the far-sided active regions which are just beyond the eastern limb. Despite the relative position, this region produced a modest increase in electrons following a large CME early on 03 January.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: ACE EPAM Protons. Low Energy Protons increased slightly around 03/1400 UTC resulting from large occulted flare over eastern limb.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been largely at high levels during the past 24 hours, although has recently become Moderate to Background again due to modest Geomagnetic activity associated with a Sector Boundary Crossing of the Heliospheric Current Sheet and/or arrival of a CME at Earth. Broadly lower electron counts at GEO are anticipated to continue for a time ahead of the onset of further Geomagnetic activity associated with one or more HSS forecast to arrive either late 04 or early 05 January (Day 1 or 2). The timing of the onset of these features will determine if electron counts can rise again briefly up to High levels on the 04 and 05 January, before more persistently subdued counts are observed. Later on 06 and 07 January (Day 3 and 4), electron flux should rise again to High levels as geomagnetic activity subsides and the electron belts likely rebound.

Electron fluence will remain above the Active threshold early on 04 January, but given current trends in electron flux is likely to fall below at some stage of the day. There is lower confidence in the fluence forecast from later on 04 into 05 January, as the overall level will be dependent on the balance between the strength of the solar wind and the magnitude of any geomagnetic activity. Based on the lower than average confidence in forecast potential effects of the coronal hole connections, the forecast calls for a balanced risk between a chance and expected Active fluence from Day 2 onwards.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	50	50	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES 16 Electron Flux

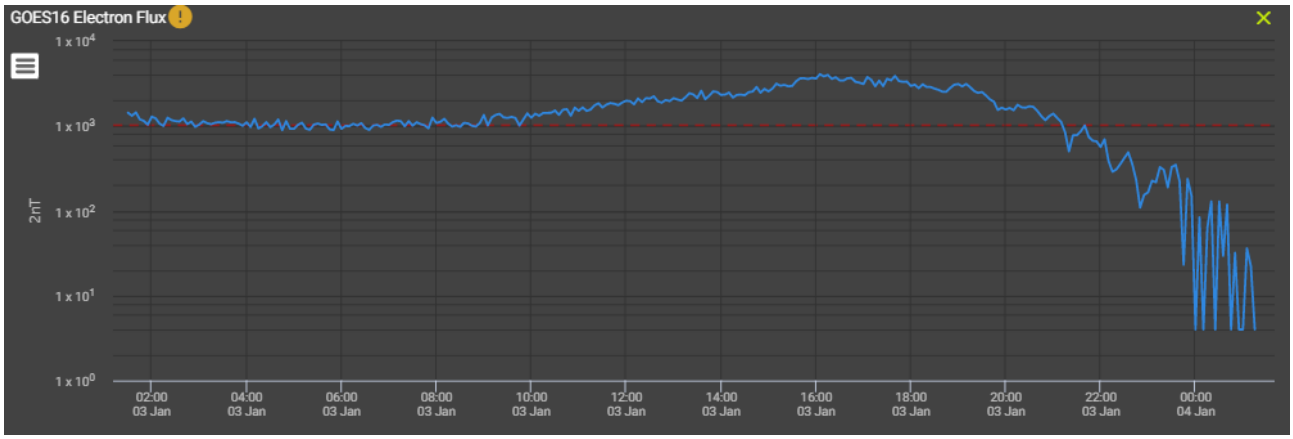

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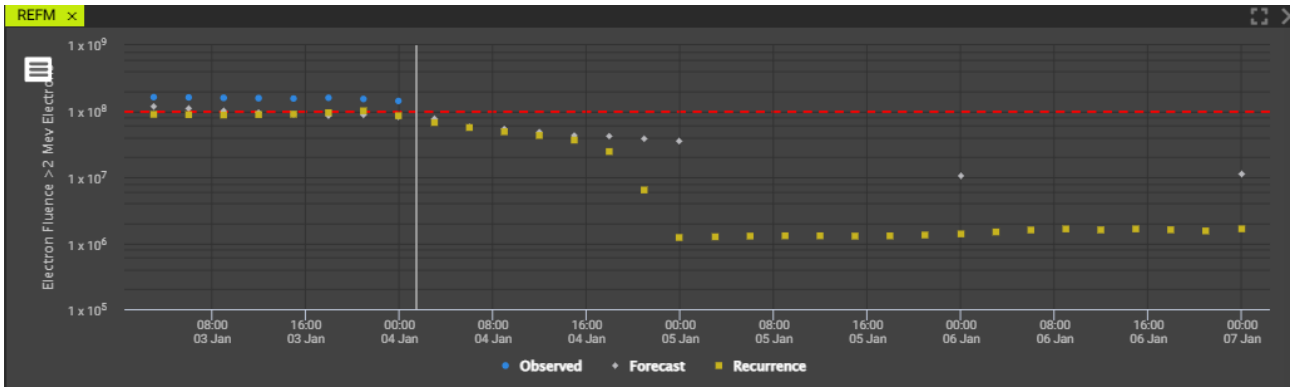
Figure 5: GOES 16 Electron Flux MOSWOC REFM forecast



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